

INCH-POUND

MIL-PRF-39014H
W/AMENDMENT 1
5 November 2010
SUPERSEDING
MIL-PRF-39014H
27 August 2010

PERFORMANCE SPECIFICATION

CAPACITOR, FIXED, CERAMIC DIELECTRIC (GENERAL PURPOSE), ESTABLISHED RELIABILITY AND NON-ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

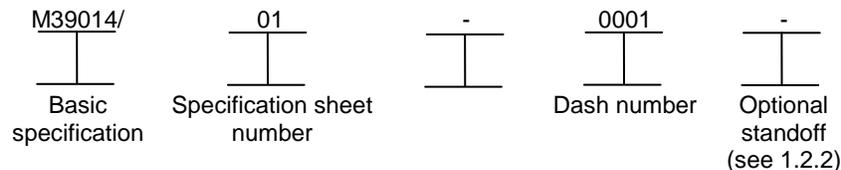
This specification is approved for use by all Departments
and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability (ER) and non-established reliability (non-ER), (product level C), general purpose, ceramic dielectric, insulated, fixed capacitors for use in applications where appreciable variations in capacitance with respect to temperature, voltage, frequency, and life can be tolerated (see 6.1). ER capacitors covered by this specification have failure rate levels (FRL) (M, P, R, and S) ranging from 1.0 percent to 0.001 percent per 1,000 hours. These FRLs are established at a 90-percent confidence level and maintained at a 10-percent producer's risk and are based on life tests performed at maximum rated voltage at maximum rated temperature. An acceleration factor of 8:1 has been used to relate life test data obtained at 200 percent of rated voltage at maximum rated temperature, to rated voltage at rated temperature.

1.2 Classification.

1.2.1 Part or Identifying Number (PIN). The PIN is in the following form, and as specified (see 3.1).



1.2.2 Optional standoff. CKR05 (MIL-PRF-39014/1) or CKR06 (MIL-PRF-39014/2) parts with optional standoff have a "V" at the end of the PIN. This location is blank for all other parts.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of the documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Comments, suggestions, or questions on this document should be addressed to: US Army Communications-Electronics RDEC, ATTN: RDER-PRQ-QE, Fort Monmouth, NJ 07703-5023, or E-mail to robert.francis@us.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.daps.dla.mil>.

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2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

(See supplement 1 for list of associated specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

- MIL-STD-202 - Electronic and Electrical Component Parts, Test Methods for.
- MIL-STD-690 - Failure Rate Sampling Plans and Procedures.
- MIL-STD-790 - Standard Practice for Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic, and Fiber Optic Parts Specifications.
- MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests.
- MIL-STD-1276 - Leads for Electronic Component Parts.

(Copies of these documents are available online at <https://assist.daps.dla.mil/quicksearch/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

TECHAMERICA

- EIA-554-1 - Assessment of Average Outgoing Quality Levels in Parts Per Million (ppm). (DoD Adopted).
- EIA-557 - Statistical Process Control Systems. (DoD Adopted).

(Copies of these documents are available from <http://techamerica.org/standards> or TechAmerica, 1401 Wilson Boulevard, Suite 1100, Arlington, VA 22209.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern (see 6.2).

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) at the time of contract award (see 4.4 and 6.3). In addition, the manufacturer shall obtain certification from the qualifying activity that the QPL system requirements of 3.3 and 4.2 have been met and are being maintained. Authorized distributors which are approved to MIL-STD-790 distributor requirements by the QPL manufacturer are listed in the QPL.

3.3 QPL system. The manufacturer shall establish and maintain a QPL system for parts covered by this specification. Requirements for this system are specified in MIL-STD-690 (ER parts only) and MIL-STD-790. In addition, the manufacturer shall establish a Statistical Process Control (SPC) and Part Per Million (ppm) system that meets the requirements specified in 3.3.1 and 3.3.2.

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3.3.1 SPC system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a SPC system that meets the requirements of EIA-557. The manufacturer shall demonstrate control of the temperature coefficient of capacitance and lead integrity in the process.

3.3.2 PPM system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a ppm system for assessing the average outgoing quality of lots in accordance with EIA-554-1. Data exclusion, in accordance with EIA-554-1 may be used with approval of the qualifying activity. The ppm system shall identify the ppm rate at the end of each month and shall be based on a six month moving average. Style reporting may include both non-ER and ER style combinations.

3.4 Material. The material shall be as specified herein. However, when a definite material is not specified, a material shall be used which enables the capacitors to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guarantee of the acceptance of the finished product.

3.4.1 Insulating and impregnating compounds. Insulating and impregnating compounds, including resins, varnishes, waxes, and the like, shall be suitable for each particular application. Compounds shall preserve the electrical characteristics of the insulation to which they are applied.

3.5 Interface and physical dimension requirements. Capacitors shall meet the interface requirements and physical dimensions specified (see 3.1).

3.5.1 Terminal lead finish. The terminal lead finish shall be in accordance with code 32 and code 52 of MIL-STD-1276. (NOTE: The 200 microinch maximum dimension for code 52 is not applicable).

* 3.5.1.1 Pure tin. The use of pure tin, as an underplate or final finish, is prohibited both internally and externally. Tin content of capacitor components and solder shall not exceed 97 percent, by mass. Tin shall be alloyed with a minimum of 3 percent lead, by mass (see 6.7). The use of lead-free tin alloy high temperature solders for internal connections requires approval by the qualifying activity. The tin content of lead-free tin alloy high temperature solders shall not exceed 97 percent by mass.

3.5.2 Solder dip (retinning). The manufacturer (or their authorized category C distributor) may solder dip/retin the leads of capacitors supplied to this specification, provided the solder dip process (see Appendix A) has been approved by the qualifying activity.

3.6 Thermal shock and voltage conditioning. When tested as specified in 4.7.2, capacitors shall withstand the extremes of high and low temperatures without visible damage and meet the following requirements:

- a. Dielectric withstanding voltage (DWV) (at +25°C): As specified in 3.9. Not applicable if optional voltage conditioning was performed at or above 250 percent of rated voltage.
- b. Insulation resistance (IR) (at +25°C): Unless otherwise specified, (see 3.1), shall not be less than the value shown on figure 1.
- c. Insulation resistance (IR) (at elevated ambient temperature): Unless otherwise specified (see 3.1), shall not be less than the value shown on figure 1.
- d. Dissipation factor (DF) (at +25°C): Shall not exceed the value specified (see 3.1).
- e. Capacitance (at +25°C): Shall be within the tolerance specified (see 3.1).

3.7 Capacitance. When measured as specified in 4.7.3, the capacitance shall be within the specified tolerance (see 3.1).

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3.8 Dissipation factor (DF). When measured as specified in 4.7.4, the DF shall not exceed the percent specified (see 3.1).

3.9 Dielectric withstanding voltage (DWV). Capacitors shall withstand direct current (dc) potential specified in 4.7.5 without damage or breakdown.

3.10 Barometric pressure (qualification only). Capacitors shall withstand the dc potential specified in 4.7.6 without flashover or damage.

3.11 Insulation resistance (IR). Unless otherwise specified (see 3.1), when measured as specified in 4.7.7, the Insulation resistance shall be not less than the value specified on figure 1.

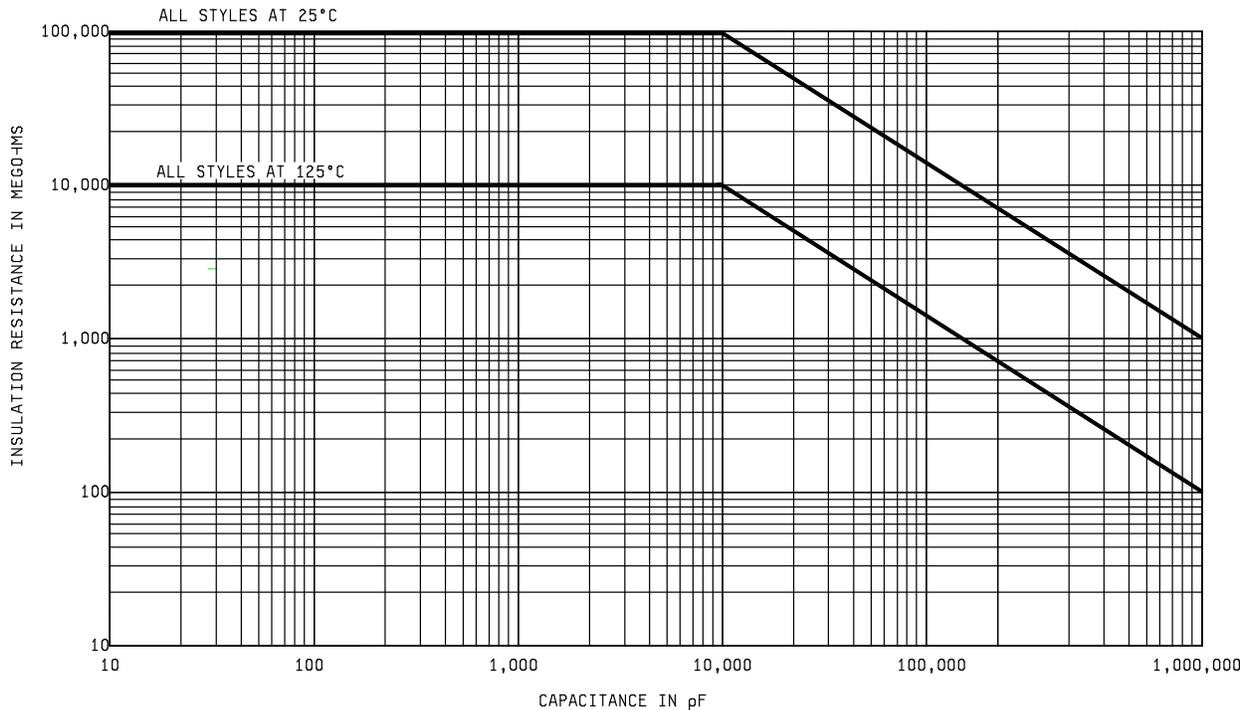


FIGURE 1. Insulation resistance versus capacitance.

3.12 Solderability. When capacitors are tested as specified in 4.7.8, the dipped surface of the leads shall be at least 95 percent covered with a new, smooth solder coating. The remaining 5 percent may contain only small pinholes or rough spots, and these shall not be concentrated in one area. Bare base metal where the solder dip failed to cover the original coating is an indication of poor solderability and shall be cause for failure. In case of dispute, the percentage of coverage with pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.13 Voltage-temperature limits. The capacitance change over the range of temperatures specified in 4.7.9 shall not exceed the limits specified (see 3.1). The capacitance value obtained in step C of table VI shall be considered the reference point.

3.14 Vibration, high frequency. When capacitors are tested as specified in 4.7.10, there shall be no intermittent contacts of 0.5 millisecond (ms) or greater duration, open-circuiting or short-circuiting, or evidence of mechanical damage.

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3.15 Immersion. When tested as specified in 4.7.11, capacitors shall meet the following requirements:

- a. Visual examination: No mechanical damage. Marking shall remain legible.
- b. DWV: As specified in 3.9.
- c. IR: Not less than the value specified (see 3.1).
- d. Capacitance: Unless otherwise specified (see 3.1), change not to exceed ± 10 percent of initial measured value.
- e. DF: Shall not exceed initial limits.

3.16 Salt atmosphere (corrosion) (applicable as specified (see 3.1)). When tested as specified in 4.7.12, there shall be no harmful or extensive corrosion, and at least 90 percent of any exposed metallic surfaces of the capacitor shall be protected by the finish. There shall be no mechanical damage to insulating surfaces. In addition, corrosion of the mounting hardware or of the terminals shall not exceed 10 percent of the surface area. Marking shall remain legible after the test.

3.17 Shock, specified pulse. When tested as specified in 4.7.13, there shall be no momentary or intermittent contact of 0.5 ms or greater duration, open-circuiting or short-circuiting, or other evidence of breakdown, arcing, and mechanical damage.

3.18 Terminal strength (applicable unless otherwise specified, see 3.1). When capacitors are tested as specified in 4.7.14, there shall be no loosening or rupturing of the terminals.

3.19 Moisture resistance. When tested as specified in 4.7.15, capacitors shall meet the following requirements:

- a. Visual examination: No mechanical damage. Marking shall remain legible.
- b. DWV: As specified in 3.9.
- c. IR: Unless otherwise specified (see 3.1), not less than 10 percent of the initial +25°C requirement.
- d. Capacitance: Unless otherwise specified (see 3.1), change not to exceed ± 10 percent from initial measured value.

3.20 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.16. When capacitors are tested as specified in 4.7.16, examination shall not disclose evidence of fungus growth on the external surface.

3.21 Resistance to soldering heat. When tested as specified in 4.7.17, capacitors shall meet the following requirements:

- a. IR at +25°C: Unless otherwise specified (see 3.1), not less than the initial +25°C requirement.
- b. Capacitance: Shall change not more than the percent specified (see 3.1) from the initial measured value.
- c. DF: Shall not exceed the initial limits.

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3.22 Resistance to solvents. When capacitors are tested as specified in 4.7.18, there shall be no evidence of mechanical damage and the marking shall remain legible.

- a. INK: Capacitors that are marked with ink (INK) or that are laser etched and back filled with ink shall be examined in qualification inspection and group A.
- b. OLM: Capacitors that the bodies are over-coated and then laser marked (OLM) shall be examined in qualification inspection and group A.
- c. NLM: Capacitors that the bodies are not over-coated prior to laser marking (NLM) and are etched directly into the bodies shall be examined in qualification inspection and group B.

3.23 Life (at elevated ambient temperature). When tested as specified in 4.7.19, capacitors shall meet the following requirements:

- a. IR (at elevated ambient temperature): Shall be not less than the value specified (see 3.1).
- b. Visual examination: No mechanical damage. Marking shall remain legible.
- c. IR (at +25°C): Shall be not less than the value specified (see 3.1).
- d. Capacitance: Change not to exceed the percent specified from the initial measured value (see 3.1).
- e. DF: Shall not exceed the value specified (see 3.1).

3.24 Low temperature storage. When tested as specified in 4.7.20, capacitors shall withstand the low temperature specified without evidence of mechanical damage.

3.25 Radiographic inspection (for qualification and FRL "S", when specified, see 3.1). When capacitors are tested as specified in 4.7.21, radiographic examination shall not disclose evidence of improperly made connections, substandard soldering or structural weakness, or attached solder particles or slivers.

3.26 Marking. Capacitors shall be marked as specified herein. Paper labels shall not be used. Other markings which in any way interfere with, obscure, or confuse those specified herein, are prohibited. Each capacitor shall be legibly marked with smear-resistant ink that will withstand the environmental conditions specified herein. At the option of the manufacturer, capacitors may be laser marked. The marking shall remain legible after all tests.

3.26.1 Marking legibility (laser marking only). When tested as specified in 4.7.1.1 the marking shall remain legible.

3.26.2 Product level substitution. A manufacturer may supply to all higher FRLs than to which they are qualified. Items of an exponential FRL as shown in table I and marked to lower FRL's with acquiring agency approval, are substitutable for higher FRL's, and shall not be remarked unless specified in the contract or order (see 6.2), the lot date codes on the parts are unchanged, and the workmanship criteria is met.

TABLE I. Product level substitutability.

Parts qualified to product level	Are substitutable for product level
S	R, P, M, and C
R	P, M, and C
P	M and C
M	C
C	

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3.26.3 Substitution of capacitance tolerance and voltage. Parts qualified and marked to tighter capacitance tolerance or higher rated voltage, with acquiring agency approval, are substitutable for parts marked to looser capacitance tolerance or lower rated voltage, provided all other values, such as case size, characteristic, and leads are the same. The substitutable parts shall not be remarked unless specified in the contract or order (see 6.2), the lot date code on the parts are unchanged, and the workmanship criteria is met.

3.26.4 "JAN" and "J" marking. The United States Government has adopted, and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of specifications. Accordingly, items acquired to, and meeting all of the criteria specified herein and in applicable specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the part number except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets, the manufacturer shall remove completely the military part number and the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN" and Registration Number 1,586,261 for the certification mark "J".

3.26.5 Full marking. Unless otherwise specified (see 3.1), capacitors shall be marked with the "JAN" or "J" marking, PIN, date code and lot number, manufacturer's name (not trademark) or the Commercial and Government Entity (CAGE) code, voltage, capacitance, and capacitance tolerance. There shall be no space between the symbols which comprise the PIN. The date code and lot number shall consist of the year, week, and lot code. For example: the twentieth week of 2005 would be 0520.

At the option of the manufacturer, the marking may be placed on one side of the capacitor, in the same order as shown in the example. Additional marking is permitted, following the required marking or on the opposite side, provided it conforms to 3.26.

EXAMPLE:

	<u>Front</u>	<u>Back</u>	
Abbreviated PIN -----	M39014	0520A	- Date and lot codes
	2-1201	J 100 V	- "J" brand and voltage rating
CAGE code -----	12345	122 K	- Capacitance and tolerance

NOTE: This example is for radial lead and disc styles. Tubular styles will be marked as above except it shall appear as six lines, front followed by back, in the order shown. For those specification sheets providing non-ER (C level) parts, the marking shall be as shown in the example, using the C level part or identifying number (PIN).

3.27 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.28 Workmanship. Capacitors shall be processed in such a manner as to be uniform in quality when using 2X minimum to 4X maximum magnification. External leads shall not exhibit cuts, nicks, or scrapes exceeding 10 percent of the diameter for round and flat lead wire parts, except as follows:

- a. Round leads: Within .050 inch (1.27 mm) of the body of the component, 10 percent of the surface area of the leads may exhibit bare base metal. These capacitors are not expected to be solderable within .050 inch (1.27 mm) of the case.
- b. Flat leads (styles [CKR22](#), [CKR23](#), and [CKR24](#)): Surface of lead may exhibit bare base metal on edges except on installation portion of lead. These capacitor leads are not expected to be solderable above the plane of the body mounting base.

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4. VERIFICATION

4.1 Classification of inspections. The inspections specified herein are classified as follows:

- a. Qualification inspection (see 4.4).
- b. Verification of qualification (see 4.5).
- c. Conformance inspection (see 4.6).
- d. Periodic group B inspection (see 4.6.2).

4.2 QPL system. The manufacturer shall establish and maintain a QPL system in accordance with 3.3. Evidence of such compliance is a prerequisite for qualification and retention of qualification.

4.3 Inspection conditions and methods.

4.3.1 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the "GENERAL REQUIREMENTS" of MIL-STD-202 except relative humidity shall not exceed 75 percent. Accuracy of all test voltage measurements shall be within ± 2.0 percent of the specified voltage.

4.3.2 Methods.

4.3.2.1 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at $+25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.3.3 Power supply. The power supply used for life testing shall have a regulation of ± 2 percent, or less, of the applicable applied test voltage.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors to be submitted to qualification inspection shall be as specified in table II and appendix A of this specification. Each capacitor style shall be qualified separately.

4.4.2 Inspection routine. Sample units shall be subjected to the qualification inspection specified in table II, in the order shown. All sample units shall be subjected to the inspection of group I and group II. The sample shall then be divided as specified in table II for group III through group VII inclusive and subjected to the tests for their particular group. Samples which have been selected to be submitted to the life test shall be divided into two groups. One group shall be subjected to the accelerated condition and the other group to the rated condition. The decision as to whether or not the product is to be included on the QPL shall be made at the conclusion of the 1,000-hour life test. Each unit subjected to the accelerated condition shall be continued on for a total of 4,000 hours. Each unit subjected to the rated condition shall be continued on for a total of 32,000 hours.

4.4.3 Failures. Failures in excess of those allowed in table II shall be cause for refusal to grant qualification approval.

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TABLE II. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted <u>1/</u>		
<u>Group I</u>						
Thermal shock and voltage conditioning	3.6	4.7.2	All units	Not applicable		
Radiographic inspection	3.25	4.7.21	All units	Not applicable		
<u>Group II</u> <u>2/</u>						
Visual and mechanical examination: Material, design, and construction Workmanship Physical dimensions and marking	3.4 to 3.5.1.1 3.28 3.1 and 3.26 to 3.26.5	4.7.1	192 <u>3/</u>	1		
Capacitance	3.7	4.7.3				
DF	3.8	4.7.4				
DWV	3.9	4.7.5				
Barometric pressure	3.10	4.7.6				
IR	3.11	4.7.7				
<u>Group III</u>						
Low temperature storage	3.24	4.7.20	6	1	1	
Solderability	3.12	4.7.8				
<u>Group IV</u>						
Voltage-temperature limits	3.13	4.7.9	18	1		
Vibration, high frequency	3.14	4.7.10				
Immersion	3.15	4.7.11				
Salt atmosphere (corrosion)	3.16	4.7.12				
<u>Group V</u>						
Shock, specified pulse	3.17	4.7.13	18	1		
Terminal strength <u>4/</u>	3.18	4.7.14				
Resistance to soldering heat	3.21	4.7.17				
Moisture resistance	3.19	4.7.15				
<u>Group VI</u>						
Fungus <u>5/</u>	3.20	4.7.16	4	1		
Resistance to solvents (INK, OLM, and NLM)	3.22	4.7.18	6			
<u>Group VII</u>						
Life (accelerated condition)	3.23	4.7.19.1	37	1		
Life (rated condition)	3.23	4.7.19.1	102			

1/ A sample unit having one or more defects will be charged as a single defective.

2/ Nondestructive examinations and tests.

3/ One additional sample unit is included in each sample of 192 sample units to permit substitution for the permitted defective in group II.

4/ Applicable, unless otherwise specified, (see 3.1).

5/ Certification of fungus resistance may be substituted for testing.

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4.4.4 FRL and quality level verification.

4.4.4.1 Failure rate (FR) qualification and lot conformance FR inspection. FR qualification and lot conformance FR inspection shall be in accordance with the general and detailed requirements of [MIL-STD-690](#) and the following details:

- a. Procedure I: Qualification at the initial FR level. Level M (1.0 percent) of FRSP-90 shall apply. Sample units shall be subjected to the qualification inspection specified in group VII, [table II](#) (see [4.7.19.3.1](#)).
- b. Procedure II: Extension of qualification to lower FRLs. To extend qualification to the P (0.1 percent) FRL, data from two or more voltages within a style and of similar construction (see [4.6.1.1.1](#)) may be combined. For FR levels R and S, two or more styles of similar construction may be combined.
- c. Procedure III: Maintenance of FRL qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification (see 4.5e). Styles in a group (see [4.6.1.1.1](#)) may be combined for FRL R and S; however, at least FRL P must be maintained on each style. Styles in group 1 and group 2 may be combined for levels R and S; however, at least FRL P must be maintained on each style.

4.4.4.2 Quality level verification. The manufacturer is responsible for establishing a quality system to verify the ppm defect level of lots that are subjected to the group A inspections. The ppm defect level shall be based on a 6-month moving average.

4.5 Verification of qualification. Every 6 months, the manufacturer shall provide verification of qualification to the qualifying activity. Continued qualification is based on meeting the following requirements:

- a. [MIL-STD-790](#) program.
- b. The capacitor design has not been modified.
- c. Lot rejection for group A inspection does not exceed 10 percent or one lot, whichever is greater.
- d. The requirements for group B inspection are met.
- e. Verification of FRLs.
- f. PPM assessment. This information shall be submitted in accordance with the style groupings listed in [4.6.1.1.1](#).
- g. Continued qualification to non-ER (C level) shall be based upon continued maintenance of qualification for the ER part (FRL R).

4.6 Conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

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4.6.1.1 Inspection and production lot.

4.6.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors of one or more styles and voltage-temperature limits, from the same production line or lines, produced under essentially the same conditions and offered for inspection during a single work week. Each lot shall be kept separate from every other lot. The sample from the lot shall be representative of the styles and highest capacitance values in the lot. All sample units belonging to a lot shall be identified by means of a code symbol (either letters or numbers, at the option of the manufacturer). The following styles are considered to be of similar construction and may be combined:

<u>Group</u>	<u>Style</u>
1	CKR04, CKR05
2	CKR06, CKR08
3	CKR11, CKR12, CKR14, CKR15, CKR16 (voltage temperature limits may be combined)
4	CKR22, CKR23, CKR24

4.6.1.1.2 Production lot. A production lot shall consist of all capacitors of the same style, voltage rating, nominal capacitance value, voltage-temperature characteristic, and termination finish. Manufacture of all parts in the lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle.

4.6.1.2 Group A inspection.

4.6.1.2.1 Non-ER capacitors. The manufacturer shall establish and maintain an inspection system to verify that capacitors meet the capacitance, DF, IR (at +25°C), visual/mechanical, and solderability requirements. In-line or process control may be part of such system. The inspection system shall also include criteria for lot rejection and corrective actions. The inspection system shall be verified under the overall MIL-STD-790 QPL system. NOTE: Since the non-ER (C-level) is the ER design without the mandatory conformance inspection and FRL assessment, this product is still expected to meet the environmental qualification requirements such as thermal shock, shock, vibration, and moisture resistance.

4.6.1.2.2 ER capacitors. Group A inspection shall consist of the examinations and tests specified in [table III](#), in the order shown.

4.6.1.2.2.1 Subgroup 1 test. Subgroup 1 tests shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the tests of subgroup 1 shall be removed from the lot. If during the 100 percent inspection, screening requires that more than 8 percent of the capacitors be discarded, the entire production lot shall be rejected.

4.6.1.2.2.2 Manufacturer's production inspection. If the manufacturer performs tests equal to or more stringent than those specified in subgroup 1 or subgroup 2 of [table III](#) as the final step of the production process, group A, subgroup 1 or subgroup 2 may be waived and the data resulting from the manufacturer's production tests may be used instead. Authority to waive the subgroup 1 or subgroup 2 inspections shall be granted by the qualifying activity only. The following criteria shall be complied with:

- a. Tests conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1 or subgroup 2.
- b. Manufacturer subjects 100 percent of the product supplied under this specification to his production tests.
- c. The parameters measured and the failure criteria shall be the same as or more stringent than those specified herein.
- d. The lot rejection criteria is the same as or more stringent than that specified herein.
- e. Once approved, the manufacturer shall not change the test procedures or criteria without prior notification and concurrence by the qualifying activity.

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4.6.1.2.2.3 Rejected lots. Production lots exceeding the eight percent defective allowable (PDA) of group A, subgroup 1 inspection shall be segregated from new lots and lots that have passed inspection. Lots rejected may be offered for acceptance only if the manufacturer 100 percent retests to the requirements of subgroup 1. Resubmitted lots shall be kept separate and shall be clearly identified as resubmitted lots. If, during the 100 percent reinspection to subgroup 1, the lot exceeds 3 percent defective, the lot shall be rejected and shall not be resubmitted.

TABLE III. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u> Thermal shock and voltage conditioning <u>1/</u>	3.6	4.7.2	100 percent inspection
<u>Subgroup 2</u> Radiograph inspection (FRL S only)	3.25	4.7.21	100 percent inspection
<u>Subgroup 3</u> Visual and mechanical examination <u>2/ 3/</u>	3.4, 3.4.1, 3.5, 3.5.1, 3.27, 3.28	4.7.1	See table IV
<u>Subgroup 4</u> Solderability <u>4/</u>	3.12	4.7.8	5 samples, 0 failures

- 1/ Post checks are required in accordance with 3.6.
- 2/ Marking defects are based on visual examination only. Any subsequent electrical defects shall not be used as a basis for determining marking defects.
- 3/ The manufacturer may request the deletion of the subgroup 3, visual and mechanical examination, provided an in-line or process control system for assessing and assuring the visual and mechanical requirements are met, can be validated and approved by the qualifying activity. Deletion of this examination does not relieve the manufacturer from meeting these requirements.
- 4/ The manufacturer may request the deletion of the subgroup 4 solderability test, provided an in-line or process control system for assessing and assuring the solderability of leads can be validated and approved by the qualifying activity. Deletion of the test does not relieve the manufacturer from meeting this test requirement.

TABLE IV. Sampling plans for subgroup 3.

Lot size	Sample size
1 - 13	100%
14 - 150	13
151 - 280	20
281 - 500	29
501 - 1,200	34
1,201 - 3,200	42
3,201 - 10,000	50
10,001 - 35,000	60
35,001 - 150,000	74
150,001 - 500,000	90
500,001 - up	102

4.6.1.2.2.4 Subgroup 2 (FRL "S" when specified, see 3.1). Capacitors shall be 100 percent inspected. Capacitors not meeting the inspection criteria shall be removed from the production lot and not supplied to this specification.

4.6.1.2.2.5 Subgroup 3.

4.6.1.2.2.5.1 Sampling plan. Subgroup 3 test shall be performed on an inspection lot basis. Samples subjected to subgroup 3 shall be selected in accordance with table IV based on the size of the inspection lot. In the event of one or more failures, the lot shall be rejected.

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4.6.1.2.2.5.2 Rejected lots. The rejected lots shall be separated from new lots and those lots that have passed inspection. The rejected lot shall be 100 percent inspected for those quality characteristics found defective in the sample and any defectives found removed from the lot. A new sample of parts shall then be randomly selected in accordance with [table IV](#). If one or more defects are found in this second sample the lot shall be rejected and shall not be supplied to this specification.

4.6.1.2.2.6 Subgroup 4 (solderability).

4.6.1.2.2.6.1 Sampling plan. Five samples shall be selected randomly from every inspection lot and subjected to the solderability test. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing. If there are one or more defects, the lot shall be rejected.

4.6.1.2.2.6.2 Rejected lots. In the event of one or more defects, the manufacturer may use one of the following options to rework the lot:

- a. Each production lot that was used to form the failed inspection lot shall be individually submitted to the solderability test as required in 4.6.1.2.2.6.1. Production lots that pass the solderability test are available for shipment. Production lots failing the solderability test can be reworked only if submitted to the reprocessing procedure in 4.6.1.2.2.6.2b.
- b. The manufacturer shall submit the failed lot to a 100 percent solder dip. Two hundred sample units from this lot shall then be subjected to all group A, subgroup 1 post-electrical tests, with no defects allowed.
 - (1) If the 200 sample units pass the group A, subgroup 1 post-electrical tests, 5 additional units shall then be subjected to the solderability test, with no defects allowed. If there are one or more defects, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.
 - (2) If the 200 sample units fail group A, subgroup 1 post-electrical tests, these tests shall be performed on 100 percent of the lot. The lot must meet the PDA requirements as specified in [4.6.1.2.2.1](#). If the PDA requirements are not met, the lot shall be considered rejected and shall not be furnished against the requirements of this specification. If the PDA requirements are met, 5 sample units shall be subjected to the solderability testing criteria of 4.6.1.2.2.6.2 b (1).

4.6.1.2.2.6.3 Disposition of samples. The solderability test is considered a destructive test and samples submitted to the solderability test shall not be supplied on the contract or order.

4.6.1.2.2.7 PPM calculations. The manufacturer shall establish a ppm system in accordance with [3.3.2](#) for assessing and calculating average outgoing quality of capacitors. A ppm rate combining capacitance, DF, IR (+25°C), and DWV shall be assessed for lots that have passed the group A inspection. The manufacturer's ppm system shall also address rectification procedures for lots failing ppm assessment. Data from the rectification process shall not be used to calculate ppm.

4.6.2 Periodic inspection (ER only). Periodic inspection shall consist of the group B inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see [4.6.3](#)), delivery of products which have passed group A inspection shall not be delayed pending the results of these periodic inspections.

4.6.2.1 Group B inspection. Group B inspection shall consist of the tests specified in [table V](#) in the order shown, and shall be performed on sample units selected from lots that have passed group A inspection. Test data obtained shall be reviewed as part of the complete verification of qualification. Capacitor styles manufactured during that month shall be represented, as far as practical, in at least the approximate ratio of production.

4.6.2.1.1 Sampling plan.

4.6.2.1.1.1 Subgroup 1 through subgroup 3. Forty sample units shall be taken from production every 2 months and subjected to the applicable tests for their particular subgroup. Permitted failures shall be as specified in [table V](#).

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4.6.2.1.1.2 Subgroup 4. A minimum of five sample units per style of the highest capacitance value produced shall be selected from each inspection lot produced during a 2-month period. Permitted failures shall be as specified in MIL-STD-690. The accumulated data shall be used for maintenance and extension of FR qualification.

4.6.2.1.2 Disposition of sample units. Sample units which have been subjected to group B inspection shall not be delivered on the contract.

4.6.3 Noncompliance. If a sample unit fails to pass group B inspection, the manufacturer shall notify the qualifying activity and cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials and processes, and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the qualifying activity has been taken. After the corrective action has been taken, group B inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the qualifying activity). Group A inspection may be reinstated; however, final acceptance and shipment shall be withheld until the group B inspection has shown that the corrective action was successful.

TABLE V. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted <u>1/</u>
<u>Subgroup 1</u> Voltage-temperature limits <u>2/</u> Vibration, high frequency <u>3/</u> Immersion <u>3/</u> Salt atmosphere (corrosion) <u>3/</u>	<u>3.13</u> <u>3.14</u> <u>3.15</u> <u>3.16</u>	<u>4.7.9.2</u> <u>4.7.10</u> <u>4.7.11</u> <u>4.7.12</u>	18	1
<u>Subgroup 2</u> Shock, specified pulse <u>3/</u> Terminal strength <u>3/ 4/</u> Resistance to soldering heat Moisture resistance	<u>3.17</u> <u>3.18</u> <u>3.21</u> <u>3.19</u>	<u>4.7.13</u> <u>4.7.14</u> <u>4.7.17</u> <u>4.7.15</u>	18	1
<u>Subgroup 3</u> Marking legibility (laser marking only) <u>3/</u> Resistance to solvents <u>3/</u>	<u>3.26.1</u> <u>3.22</u>	<u>4.7.1.1</u> <u>4.7.18</u>	4	0
<u>Subgroup 4</u> Life (4,000 hours accelerated conditions)	<u>3.23</u>	<u>4.7.19.2.1</u>	5 minimum per style	See 4.6.2.1.1.2

1/ A sample unit having one or more defects shall be charged as a single defective.

2/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, the frequency of this test, with the approval of the qualifying activity, can be performed on an annual basis. If the design, material, construction or processing of the part is changed or, if there are any quality problems or failures, the qualifying activity may require resumption of the original test frequency.

3/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, this test, with the approval of the qualifying activity, can be deleted. The manufacturer, however, shall perform this test every three years after the deletion as part of long term design verification. If the design, material, construction or processing of the part is changed or, if there are any quality problems, the qualifying activity may require resumption of the specified testing. Deletion of testing does not relieve the manufacturer from meeting the test requirement in case of dispute.

4/ Applicable unless otherwise specified, (see 3.1).

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4.7 Methods of inspection and test.

4.7.1 Visual and mechanical examination. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements. (See 3.1, 3.4 to 3.5.1 inclusive, 3.27 and 3.28).

4.7.1.1 Marking legibility (laser marking only, see 3.26.1). Capacitors shall be coated with .005 inch (0.13 mm) minimum of silicone resin insulating compound. After curing, coated capacitors shall be examined for legibility under normal production room lighting by an inspector with normal or corrected 20/20 vision.

4.7.2 Thermal shock and voltage conditioning (see 3.6). Capacitors shall be subjected to the tests of 4.7.2.1 and 4.7.2.2, as applicable (see table II and table III).

4.7.2.1 Thermal shock. Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details and exception shall apply:

- a. Test condition A, except that in step 3, sample units shall be tested at the applicable high operating temperature (see table II and 3.1).
- b. Measurements before and after cycling: Not applicable for qualification inspection (all FRLs) and quality conformance inspection for FRLs 1.0 percent, 0.1 percent, 0.01 percent and 0.001 percent/1,000 hours.

4.7.2.2 Voltage conditioning. The intent of voltage conditioning is that all parts be exposed to a predetermined test voltage ± 5 percent, for a defined time and temperature. Voltage conditioning is done to help eliminate infant mortal capacitors from the production lot. All parts offered for electrical testing shall be subjected to the voltage conditioning test in 4.7.2.2.1 or optional voltage conditioning test in 4.7.2.2.2. It shall be verifiable that all parts offered for electrical tests have been exposed to the required voltage conditioning for the required time duration. See figure 2 for a suggested test circuit. An alternate test circuit can be used, provided the notes of figure 2 are followed. The lot traveler shall indicate which test is used. When the optional voltage conditioning test of 4.7.2.2.2 is used, the lot traveler shall include the specific accelerated voltage used and the test time.

4.7.2.2.1 Standard voltage conditioning. Voltage conditioning shall be started immediately after completion of the thermal shock test. The voltage conditioning shall consist of applying a minimum of twice the rated voltage to the unit at the maximum rated temperature $+4^{\circ}\text{C}$, -0°C for 96 hours minimum. Voltage shall be applied and shall reach maximum value within one second, maximum. Voltage conditioning failures are identified as those capacitors that fail any of the post voltage conditioning electrical tests.

After completion of the exposure period, the following electrical tests shall be performed:

- a. Insulation resistance ($+125^{\circ}\text{C}$). Note: This step may be skipped if step C is done at $+125^{\circ}\text{C}$ with $+25^{\circ}\text{C}$ test limits.
- b. Dielectric withstanding voltage.
- c. Insulation resistance ($+25^{\circ}\text{C}$).
- d. Capacitance.
- e. Dissipation factor.

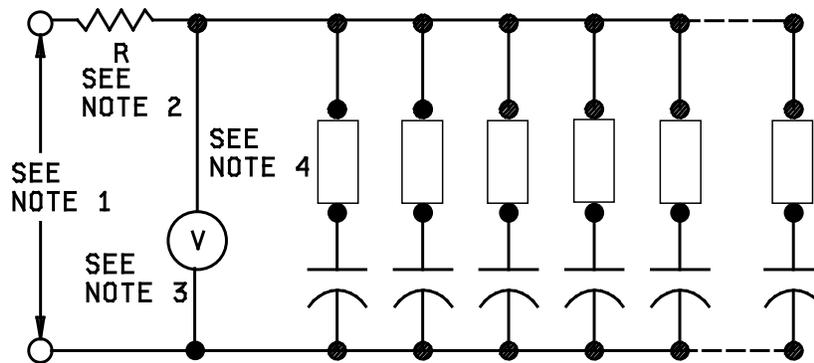
The manufacturer has the option of performing these electrical tests in any order except insulation resistance shall always be done after dielectric withstanding voltage. If the voltage conditioning test is performed with individual fuses in series with each part, any part tested in a position where a fuse fails shall be tested for insulation resistance and dielectric withstanding voltage. If the part meets the initial requirements for insulation resistance and dielectric withstanding voltage, the part shall be rejected but shall not count against the PDA. The manufacturer also has the option to not test parts with fuse failures and count these toward the PDA.

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4.7.2.2.2 Optional voltage conditioning (capacitors with voltage ratings of 200 volts or less only). The manufacturer, with approval from the qualifying activity, may perform an optional voltage conditioning test instead of the standard voltage conditioning test of 4.7.2.2.1. All conditions of 4.7.2.2.1 apply, with the exception of the voltage applied and test time. The minimum time duration, T(test), shall be calculated as follows:

$$T_{\text{test}} (\text{min.}) = \frac{800}{(E_{\text{test}} / E_{\text{rated}})^3} \quad \text{Where:} \quad 2 \times E_{\text{rated}} \leq E_{\text{test}} \leq 4 \times E_{\text{rated}}$$

E_{test} = Applied voltage
 E_{rated} = Rated voltage of the capacitor
 $T_{\text{test}} (\text{min.})$ = Minimum test time in hours



NOTES:

1. The power supply shall be capable of providing a minimum of twice the rated voltage (or four times the rated voltage if optional voltage conditioning is used) of the capacitors at 30 mA minimum, per circuit.
2. The current limiting device shall be a resistor or a fuse. The current shall be limited to no less than 30 mA and no more than 10 A.
3. There shall be a voltage monitor that will trigger an alarm and shut off the test if the applied voltage drops by more than 5 percent.
4. Fuses and resistors are optional. The value of the resistor shall be such that it does not restrict the power supply's ability to provide the required test voltage to the device under test (± 5 percent).
5. The capacitor bank shall be no less than ten capacitors.

FIGURE 2. Test circuit.

4.7.3 Capacitance (see 3.7). Capacitors shall be tested in accordance with [method 305 of MIL-STD-202](#). The following details and exception shall apply:

- a. Test frequency: 1 MHz ± 100 kHz when the nominal capacitance is 100 pF or less, and 1 kHz ± 100 Hz when the nominal capacitance is greater than 100pF.
- b. Voltage: A root-mean-square potential of 1.0 volt ± 0.2 volt, when no polarizing voltage is applied.

4.7.4 Dissipation factor (see 3.8). Unless otherwise specified (see 3.1), the DF shall be measured with a capacitance bridge or other suitable method at the frequency and voltage specified in 4.7.3a and 4.7.3b. Unless otherwise specified, the inherent accuracy of the measurement shall be ± 2 percent of the reading plus 0.1 percent DF (absolute). Suitable measurement techniques shall be used to minimize errors due to the connections between the measuring apparatus and the capacitor.

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4.7.5 Dielectric withstanding voltage (see 3.9).

4.7.5.1 Dielectric. Capacitors shall be tested in accordance with [method 301 of MIL-STD-202](#). The following details shall apply:

- a. Magnitude and nature of test voltage: Unless otherwise specified (see [3.1](#)), 250 percent of the dc rated voltage.
- b. Duration of application of test voltage: Five seconds ± 1 second. The test voltage shall be raised from 0 volts to the specified value within 1 second, maximum.
- c. Points of application of test voltage: Unless otherwise specified (see [3.1](#)), between the capacitor-element terminals.
- d. Limiting value of surge current: Shall be limited between 30 milliamperes (mA) and 50 mA.
- e. Examination after test: Capacitors shall be examined for evidence of damage and breakdown.

4.7.5.2 Body insulation (qualification only). Capacitors shall be tested as specified in 4.7.5.1 with the following exception: Points of application of test voltage: Unless otherwise specified (see [3.1](#)), capacitors shall be wrapped with a conductive tape or foil so that the conductive tape or foil shall not be less than .0625 inch (1.59 mm) and more than .125 inch (3.18 mm) away from the lead wires. A dc potential as specified (see [3.1](#)) shall be applied between the two leads connected together and the tape or foil for a period of 5 seconds ± 1 second. The test circuit shall be so arranged that the surge current does not exceed 50 mA.

4.7.6 Barometric pressure (qualification only, see 3.10). Capacitors shall be tested in accordance with [method 105 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Method of mounting: Securely fastened by their normal mounting means.
- b. Test condition D: (100,000 feet) (.315 inch (8.00 mm) of mercury).
- c. Test during subjection to reduced pressure: Unless otherwise specified (see [3.1](#)), a dc potential equal to 100 percent of the dc rated voltage applied for a period of 5 seconds ± 1 second.
- d. Points of application: Unless otherwise specified (see [3.1](#)), the test voltage shall be applied between the capacitor-element terminals.
- e. Surge current: Shall not exceed 50 mA.
- f. Examination during and after test: Capacitors shall be visually monitored for evidence of flashover or damage.

4.7.7 Insulation resistance (see 3.11). Capacitors shall be tested in accordance with [method 302 of MIL-STD-202](#). The following details shall apply:

- a. Test potential: Unless otherwise specified (see [3.1](#)), rated voltage.
- b. Special conditions: If a failure occurs at a relative humidity above 50 percent, the IR may be measured again at any relative humidity less than 50 percent.
- c. Points of measurement: Unless otherwise specified (see [3.1](#)), between the mutually insulated points.

4.7.8 Solderability (see 3.12). Capacitors shall be tested in accordance with [method 208 of MIL-STD-202](#). The following detail shall apply: Number of terminations to be tested: Two (unless otherwise specified, see [3.1](#)).

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4.7.9 Voltage-temperature limits (see 3.13).

4.7.9.1 For qualification inspection. The temperature of each capacitor shall be varied as specified in table VI. Capacitance measurements shall be made at the frequency and voltage specified in 4.7.3a and 4.7.3b. The dc rated voltage need only be applied to the capacitor in each of step E through step G until voltage stability is reached and the capacitance measurement is made. Capacitance measurements shall be made at each step specified in table VI and at a sufficient number of intermediate points between step E and step G to establish a true characteristic curve. Capacitance measurements at each temperature shall be taken at 5 minute intervals and shall be stopped and recorded when two successive readings indicate a capacitance change of less than one percent.

4.7.9.2 For conformance inspection. Capacitance measurements shall be made as specified in 4.7.9.1 except that the measurements shall be made only for step C, step D, step E, and step G of table VI.

TABLE VI. Voltage-temperature limit cycle.

Step	Voltage, dc	Temperature, °C
A	None	+25 ±2
B	None	-55 ±2
C <u>1/</u>	None	+25 ±2
D	None	Applicable high-operating temperature ±2
E	Rated	Applicable high-operating temperature ±2
F	Rated	+25 ±2
G	Rated	-55 ±2

1/ Reference point.

4.7.10 Vibration, high frequency (see 3.14). Capacitors shall be tested in accordance with [method 204 of MIL-STD-202](#). The following details and exception shall apply:

- a. Mounting: Capacitors shall be rigidly mounted on a mounting fixture by the body. For styles other than feed-through, leads shall be secured to rigidly supported terminals, so spaced that the length of each lead from the capacitor is approximately .375 inch (22.22 mm) when measured from the edge of the supporting terminal. Leads shall be within 15 degrees of being parallel; each lead in disk types shall be in the plane of the flat surface from which it extends. When securing leads, care shall be taken to avoid pinching the leads. The mounting fixture shall be so constructed as to preclude any resonances within the test range. An examination of the mounting fixture shall be made on a vibrator. If any resonant frequencies are observed, adequate steps must be taken to damp the structure.
- b. Electrical load conditions: During the test, a dc potential equal to 125 percent of the dc rated voltage (see [3.1](#)) shall be applied between the terminals of the capacitor element under test.
- c. Test condition D: (20 g's).
- d. Duration and direction of motion: Equal amounts of time in each of three mutually perpendicular planes (total of 8 hours).
- e. Measurements during vibration: During the last cycle in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration or open-circuit or short-circuiting.
- f. Examination after vibration: Capacitors shall be visually examined for evidence of mechanical damage.

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4.7.11 Immersion (see 3.15). Capacitors shall be tested in accordance with [method 104 of MIL-STD-202](#). The following details shall apply:

- a. Test condition B.
- b. Examinations and measurements after final cycle: Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking; DWV, IR, capacitance, and DF shall then be measured as specified in [4.7.5](#), [4.7.7](#), [4.7.3](#), and [4.7.4](#), respectively.

4.7.12 Salt atmosphere (corrosion) (applicable as specified (see 3.16)). Capacitors shall be tested in accordance with [method 101 of MIL-STD-202](#). The following details and exception shall apply:

- a. Test condition B.
- b. Measurements after exposure: Not applicable.
- c. Examinations and measurement after test: Capacitors shall be visually examined for evidence of harmful and extensive corrosion and obliteration of marking.

4.7.13 Shock, specified pulse (see 3.17). Capacitors shall be tested in accordance with [method 213 of MIL-STD-202](#). The following details shall apply:

- a. Mounting: Capacitor shall be rigidly mounted by the body.
- b. Test condition I: (100 g's).
- c. Measurements during shock: During the last shock in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration or open-circuit or short-circuiting.
- d. Examination after shock: Capacitors shall be visually examined for evidence of breakdown, arcing, and mechanical damage.

4.7.14 Terminal strength, when applicable (see 3.18). Capacitors shall be tested in accordance with [method 211 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test condition A, applicable to all styles. Applied force: Unless otherwise specified (see [3.1](#)), 5 pounds.
- b. Test condition C, applicable to radial-lead units only. Applied force: 1.0 pound +.1 pound, -0 pound.
- c. Test condition D, applicable to axial-lead units only.
- d. Examination after test: Capacitors shall be visually examined for evidence of loosening or rupturing of the terminals.

4.7.15 Moisture resistance (see 3.19). Capacitors shall be tested in accordance with [method 106 of MIL-STD-202](#). The following detail and exceptions shall apply:

- a. Initial measurements: Not applicable.
- b. Number of cycles: 20 continuous cycles.
- c. Step 7b: Not applicable.
- d. Loading: Unless otherwise specified (see [3.1](#)), during the first 10 cycles only, a dc potential of 100 volts or rated voltage, whichever is less, shall be applied across the capacitor terminals. Once each day, a check shall be performed to determine whether a capacitor has shorted.

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- e. Examinations and final measurement: Upon completion of step 6 of the final cycle, capacitors shall be conditioned at $+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and a relative humidity of 30 percent to 60 percent for a period of 18 hours minimum, 24 hours maximum, and shall be visually examined for evidence of mechanical damage and obliteration of marking; capacitance, DWV, and IR shall then be measured as specified in 4.7.3, 4.7.5, 4.7.5.1, 4.7.5.2, and 4.7.7, respectively.

4.7.16 Fungus (when applicable, see 3.20). Capacitors shall be tested in accordance with method 508 of MIL-STD-810.

4.7.17 Resistance to soldering heat (see 3.21). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:

- a. Surface oxides and dross shall be skimmed off the solder pot immediately before lead immersion to ensure full and complete heat flow through the leads.
- b. Depth of immersion in the molten solder: To a minimum of .050 inch, -0 inch, +.020 inch (1.27 mm -0 mm, +0.51 mm) from the capacitor body (the example shown on figure 3 is applicable to all terminal types).
- c. Test condition B, except that the immersion duration shall be 20 seconds ± 1 second.
- d. Cooling time prior to measurement after test: Unless otherwise specified, 10 minutes ± 1 minute (see 3.1).
- e. Measurements after test: Capacitance, DF, and IR at $+25^{\circ}\text{C}$ shall be measured as specified in 4.7.3, 4.7.4, and 4.7.7, respectively.
- f. Internal examination after test: Not required.

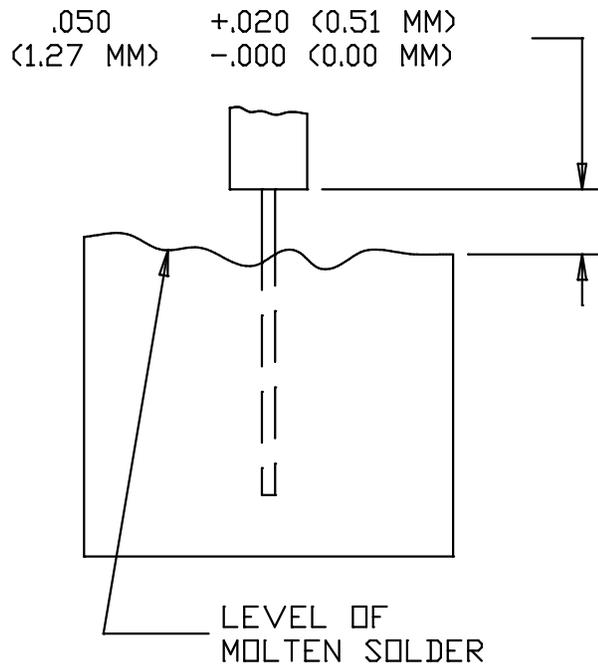


FIGURE 3. Example of axial wire-lead depth of immersion in molten solder.

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4.7.18 Resistance to solvents (see 3.22). Capacitors shall be tested in accordance with [method 215 of MIL-STD-202](#). The following details shall apply:

- a. The marked portion of the capacitor body shall be brushed.
- b. The number of sample units to be examined shall be as specified in [table II](#).
- c. Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking.

4.7.19 Life (at elevated ambient temperature) (see 3.23).

4.7.19.1 For qualification inspection. Capacitors shall be tested in accordance with [method 108 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Distance of temperature measurements from specimens, in inches: Not applicable.
- b. Operating conditions: Capacitors shall be subjected to the applicable high operating temperature, +4°C, -0°C (see [3.1](#)) at 200 percent \pm 2 percent of the rated dc voltage.
- c. Operating conditions: Capacitors tested under rated conditions shall be subjected to the dc rated voltage, \pm 2 percent.
- d. Test condition D: (1,000 hours).
- e. Measurements during and after exposure: At the conclusion of this test and while the capacitors are at the applicable high-test temperature, the IR shall be measured as specified in [4.7.7](#). At the option of the manufacturer, the units may be immediately transferred (period of transfer not to exceed 15 minutes) to another chamber maintained at the same temperature for the purpose of measuring IR. The IR measurement shall be made only after the units have stabilized at the test temperature. The capacitors shall then be returned to the inspection conditions specified in [4.3](#) and shall be visually examined for evidence of mechanical damage and obliteration of marking; IR, capacitance, and DF, shall be measured as specified in [4.7.7](#), [4.7.3](#), and [4.7.4](#), respectively.

4.7.19.2 For conformance inspection.

4.7.19.2.1 For FRL "M", "P", "R", and "S". Capacitors shall be tested as specified in [4.7.19.1](#), except that duration of test will be 4,000 hours (accelerated condition only).

4.7.19.3 Extended life test.

4.7.19.3.1 For qualification inspection. Sample units which have been subjected to 1,000 hours of life under rated conditions shall be continued on test for a total of 32,000 hours. Sample units which have been subjected to 1,000 hours of life test under accelerated conditions shall be continued on test for a total of 4,000 hours. Measurements as specified in [4.7.19.1](#) shall be taken every 1,000 hours +48 hours, -0 hours for the first 10,000 hours and then after every 5,000 hours +96 hours, -0 hours until a total of 32,000 hours +96 hours, -1 hour have passed.

4.7.20 Low temperature storage (see 3.24). Capacitors shall be subjected to exposure at -65°C +0°C, -3°C for a period of 8 hours, minimum.

4.7.21 Radiographic inspection (for qualification and FRL "S", when specified, see 3.1) (see 3.25). Capacitors shall be tested in accordance with [method 209 of MIL-STD-202](#). The following details and exception shall apply:

- a. Radiographic quality: The radiograph shall render a clear sharp image of the penetrameter.
- b. Image-quality indicator: A radiograph of the penetrameter shall be included on each radiograph film. The penetrameter may be made from a sample capacitor, of the same style as the capacitor being radiographed, with an AWG number 48 copper wire mounted across the capacitor body or it may be fabricated in accordance with, or be equivalent to, the example on [figure 4](#).

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- c. Positions of specimen: Unless otherwise specified (see 6.2), one view shall be taken of each capacitor perpendicular to the plane of the lead surface (see figure 5).
- d. Evaluation of images:
 - (1) Special kind of viewing equipment: Magnifying glass.
 - (2) Magnification: 10X.
 - (3) Defects to be sought in specimen: As specified in 3.25.
- e. Additional required examination:
 - (1) There shall be a minimum of 80 percent solder fillet between capacitor element and each lead.
 - (2) There shall be a minimum of .005 inch (0.13 mm) encapsulating material encasing the capacitor element (see figure 6).
 - (3) There shall be a minimum of .005 inch (0.13 mm) between edge of case and tip of solder spike.
 - (4) Extraneous particles or void in encapsulating material shall not be greater than .005 inch (0.13 mm) in any dimension.
- f. Non-film techniques and real time x-ray. The use of non-film techniques such as real time x-ray is permissible if the equipment is capable of producing results of equal or better quality as the film technique and all requirements of this specification are complied with, except those pertaining to the actual film. Radiographic image-quality indicators, as specified in 4.7.21b, may be used at the beginning and end of each inspection lot if equipment settings are not modified.

NOTE: Test results (covering the number of capacitors tested with number and kind of failures notes) and radiograph shall be retained for a minimum period of 2 years. Upon request of user, this data shall be supplied with each shipment.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. These capacitors are primarily designed for use where a small physical size with comparatively large electrical capacitance and high IR is required. General purpose ceramic capacitors are not intended for frequency-determining or precision circuits but are suitable for use as by-pass, filter, and non-critical coupling elements in high-frequency circuits. All of these applications are of the type where DF is not critical and moderate changes due to temperature, voltage, and frequency variations do not affect the proper functioning of the circuit. These capacitors also offer established reliability that is verified under a qualification system.

6.1.1 Case insulation. It is not intended that the case insulation be subjected to sustained voltage in excess of 150 percent of the dc rated voltage of the capacitor. Supplementary insulation should be provided where the case may come in contact with higher voltage.

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6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification, the applicable specification sheet, and the complete PIN (see [3.1](#)).
- b. Packaging requirements.
- c. Required number of views and planes if other than that specified (see [4.7.21c](#)).
- d. Lead length, if different from that specified (applicable to performance specification sheets [MIL-PRF-39014/1](#), [MIL-PRF-39014/2](#), [MIL-PRF-39014/5](#), and [MIL-PRF-39014/23](#)). When specified, lead lengths may be a minimum of .625 inch (15.88 mm) long or 1.00 inch (25.4 mm) long, as applicable (see [3.1](#)), for use in tape and reel automatic insertion equipment.
- e. Lead finish (see [3.5.1](#)).
- f. Retinning (hot solder dip), if required.
- g. Insulation coating limits of less than .018 inch (0.46 mm) for [MIL-PRF-39014/1](#) and [MIL-PRF-39014/2](#) capacitors are negotiable with the manufacturer.
- h. Capacitor marking requirements (see [3.26.2](#) and [3.26.3](#)).

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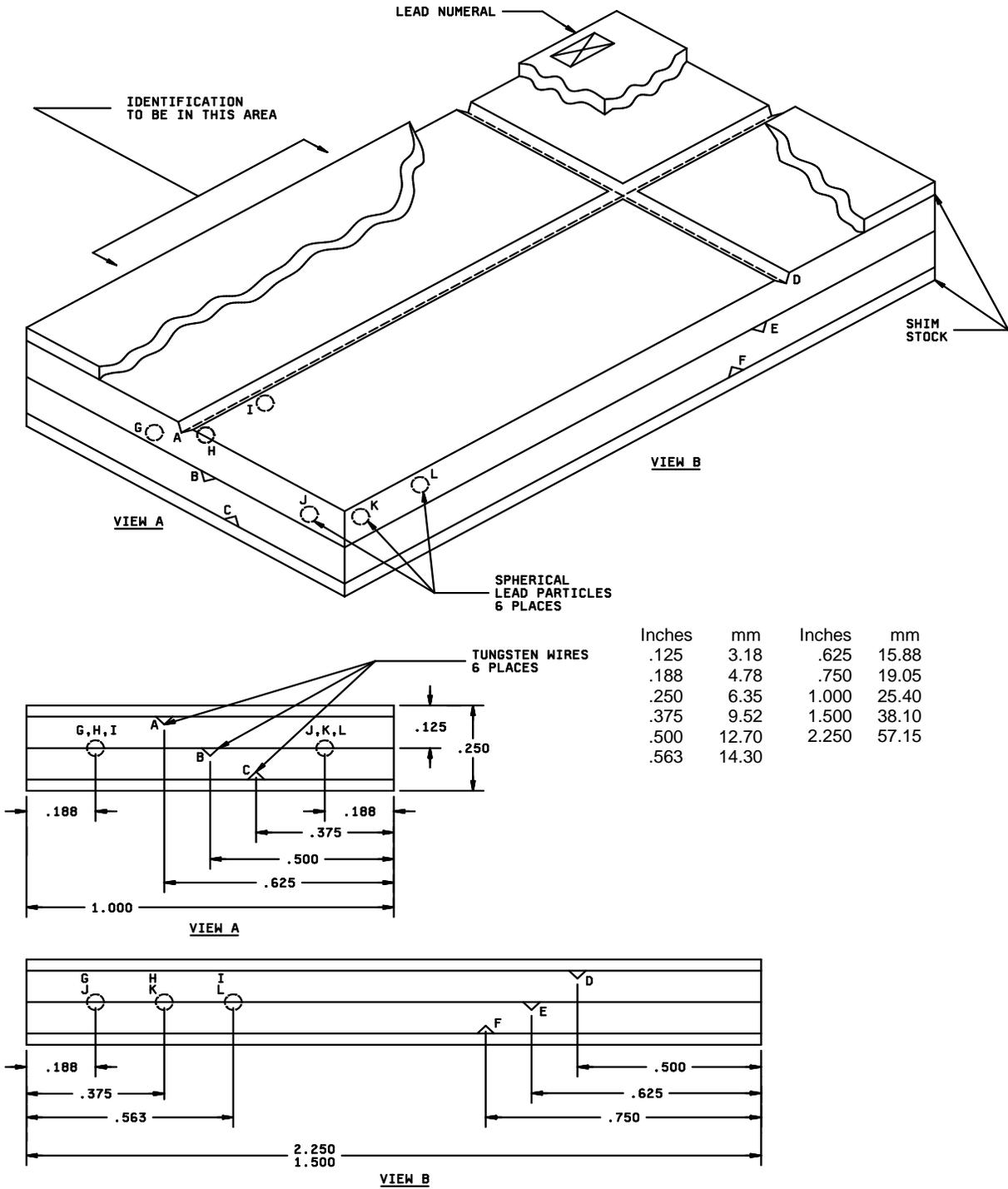


FIGURE 4. Image quality indicator (optional).

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Table of image quality indicators

Tungsten wire diameters						Lead particle diameters						Steel shim stock
A	B	C	D	E	F	G	H	I	J	K	L	
.002 (0.05)	.001 (0.03)	.0005 (0.01)	.0005 (0.01)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	None
.002 (0.05)	.001 (0.03)	.0005 (0.01)	.0005 (0.01)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.002 (0.05)
.002 (0.05)	.001 (0.03)	.0005 (0.01)	.0005 (0.01)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.005 (0.13)
.002 (0.05)	.001 (0.03)	.0005 (0.01)	.0005 (0.01)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.007 (0.18)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.010 (0.25)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.015 (0.38)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.025 (0.64)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.035 (0.89)

NOTES:

1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Millimeters are in parenthesis.
4. Wires to be tungsten, shim stock to be carbon steel, particles to be lead. Center section to be .125 inch (3.18 mm) layers of clear acrylic plastic, bonded with clear plastic cement of low X-ray density. Fasteners may be used within .250 inch (6.35 mm) from each corner, but shall not interfere with end use of the penetrometer. Bottom surface shall be flush.
5. All dimensions shown are ± 0.005 inch (0.13 mm), except wires and shim stock, which shall be within standard mil tolerances, and lead particles, which shall be ± 0.0002 inch (0.005 mm). Groove details are not critical except that wire must be embedded flush or below surface of plastic and centered at the location shown. Particle-hole sizes are not critical, but should not exceed .031 inch (0.79 mm) in diameter and depth, and must be centered as shown, ± 0.005 inch (0.13 mm).
6. Additional layers of shim stock may be used as necessary.
7. Identification marking shall be permanent and legible. Location and size of characters are not critical but shall not interfere with or obscure the radiographic image details.

FIGURE 4. Image quality indicator (optional) - Continued.

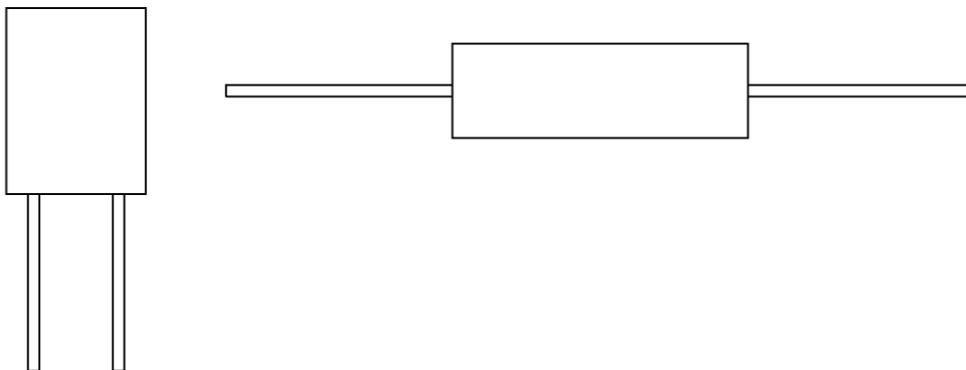


FIGURE 5. Viewing planes for radiographic inspection.

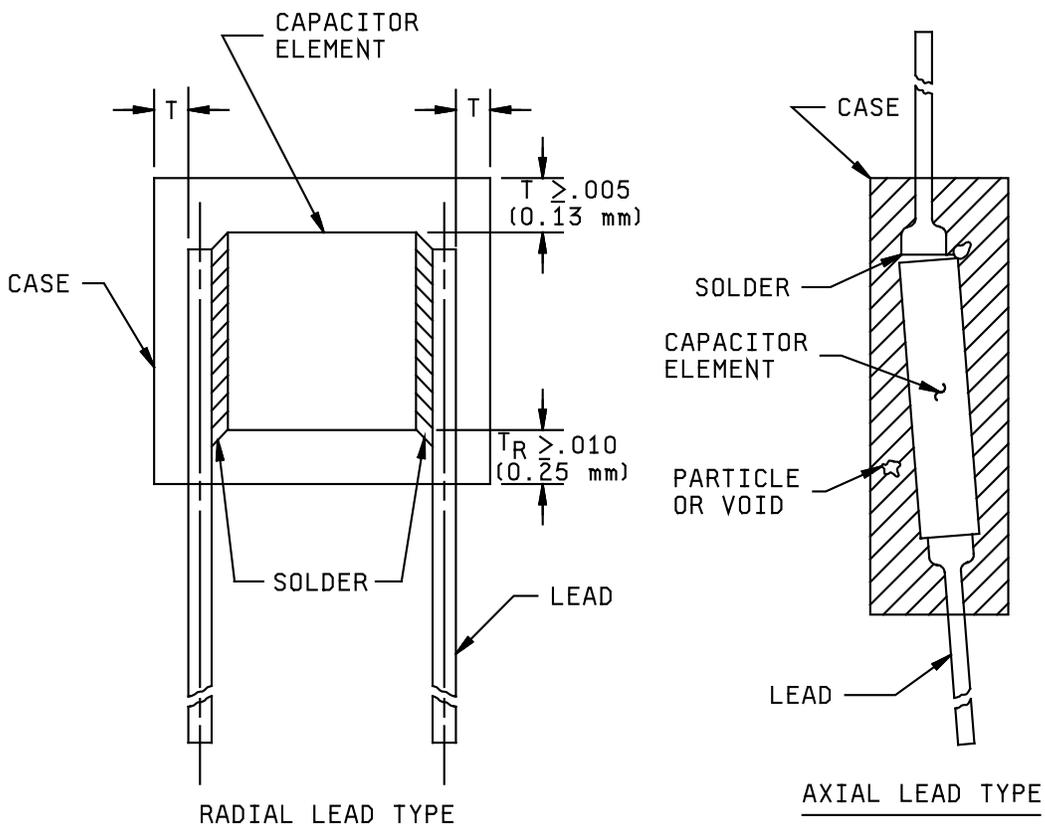
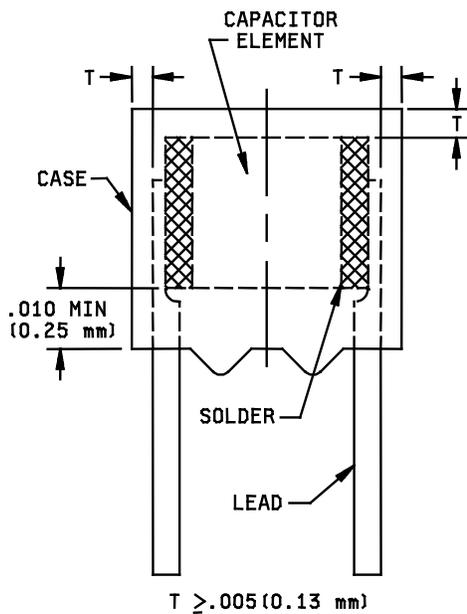
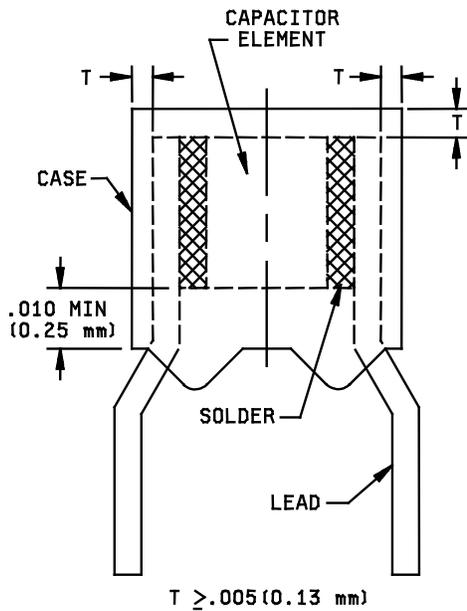


FIGURE 6. Radiographic inspection criteria.



RADIAL LEAD TYPE WITH STANDOFFS

FIGURE 6. Radiographic inspection criteria - Continued.

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6.3 Qualification. With respect to products requiring qualification, awards will be made only for products that are, at the time of award of contract, qualified for inclusion in Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the U.S. Army Communications-Electronics RDEC, ATTN: RDER-PRQ-QE, Fort Monmouth, NJ 07703-5023; however, information pertaining to qualification of products may be obtained from the DLA Land and Maritime, ATTN: VQP, PO Box 3990, Columbus, OH 43218-3990, or by E-mail to vqp.chief@dla.mil.

6.4 Standard capacitor types. Equipment designers should refer to [MIL-HDBK-198](#), Capacitor, Selection and Use Of, for standard capacitor types and selected values chosen from this specification. [MIL-HDBK-198](#) provides a selection of standard capacitors for new equipment design.

6.5 Marking of non-ER parts. An ER part manufactured in accordance with this specification may be marked and furnished as the non-ER version in accordance with [MIL-C-11015](#), if produced on the same assembly line or lines, and provided it is subjected to and meets all the inspection requirements of the ER part.

6.6 International standardization agreements. Certain provisions (see [3.1](#)) of this specification are the subject of international standardization agreement NATO-NEPR number 14. When amendment, revision, or cancellation of this specification is proposed, which will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels including departmental standardization offices, if required.

6.7 Tin whisker growth. The use of alloys with tin content greater than 97 percent by mass may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacture and can develop under typical operating conditions on parts that use such materials. Conformal coatings applied over top of whisker-prone surfaces will not prevent the formation of whiskers. Alloys of 3 percent lead, by mass, have shown to inhibit the growth of tin whiskers. For additional information, see [ASTM B545](#), "Standard Specification for Electrodeposited Coatings of Tin."

6.8 Key word listing.

Capacitance
Dissipation Factor
Parts per million (ppm)
Statistical process control (SPC)

6.9 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmental Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals and additional information is available on their website at <http://www.epa.gov/osw/hazard/wastemin/priority.htm>. Included in the EPA list of 31 priority chemicals are cadmium, lead, and mercury. Use of these materials should be minimized or eliminated unless needed to meet the requirements specified herein (see section 3).

6.10 Changes from previous issue. The margins of this specification are marked with an asterisk to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

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APPENDIX A

PROCEDURE FOR QUALIFICATION INSPECTION

A.1 SCOPE

A.1.1 Scope. This appendix details the procedure for submission of samples for qualification inspection of capacitors covered by this specification. The procedure for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

A.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

A.3 SUBMISSION

A.3.1 Sample.

A.3.1.1 Single-style submission. A sample of the size required in [table II](#), of the highest capacitance value in each voltage rating in each operating temperature range and voltage-temperature limit in each style for which qualification is sought shall be submitted. After qualification has been granted, no changes shall be made in materials, design, or construction without prior notification of the qualifying activity.

A.4 EXTENT OF QUALIFICATION

A.4.1 Single-style submission. Capacitance-range qualification will be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerances equal to and wider than the tolerance submitted. DC rated voltage qualification will be restricted to that submitted. Operating temperature range and voltage-temperature limit qualification will be restricted to that submitted.

A.4.1.1 Extension of qualification of ER. Qualification of ceramic capacitors with standoffs to similar ER and non-ER capacitors will be extended to ceramic capacitors without standoffs, as indicated in table A-I.

TABLE A-I. Extension of qualification.

Qualification to ER standoff	Will extend qualification to	
	ER without standoff	Non-ER without standoff
CKR05	CKR05	CK05 MIL-C-11015/18
CKR06	CKR06	CK06 MIL-C-11015/19

A.4.2 Product levels. Qualification of the C (non-ER) level is predicated upon meeting the qualification requirements for ER FRL "P". Since the non-ER (C level) is the ER design without the mandatory conformance inspection and FRL assessment, this product is still expected to meet the environmental requirements such as moisture resistance, thermal shock, or shock.

A.5 SOLDER DIP (RETIMMING) LEADS

A.5.1 Solder dip (retinning) leads. The manufacturer (or their authorized category C distributor) may solder dip/retin the leads of capacitors supplied to this specification provided the solder dip process has been approved by the qualifying activity.

A.5.2 Qualifying activity approval. Approval of the solder dip process will be based on one of the following options:

- a. When the original lead finish qualified was hot solder dip lead finish 52 in accordance with [MIL-STD-1276](#) (NOTE: The 200 microinch maximum thickness is not applicable). The manufacturer shall use the same solder dip process for retinning as was used in the original manufacture of the capacitor.

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- b. When the lead originally qualified was not solder dip lead finish 52 of [MIL-STD-1276](#) as prescribed in [A.5.2a](#), approval for the process to be used for solder dip shall be based on the following procedure:
- (1) Thirty samples of any capacitance value for each style and lead finish shall be subjected to the manufacturer' solder dip process. The capacitors shall then be subjected to all group A, subgroup 1 post-electrical tests, with no defects allowed. (NOTE: If radiographic inspection is required in group A, this test shall also be performed, with no defects allowed).
 - (2) Ten of the 30 samples shall then be subjected to the solderability test, with no defects allowed.
 - (3) The remaining 20 samples shall be subjected to the resistance to soldering heat test, followed by the moisture resistance test, with no defects allowed.

A.5.3 Solder dip/reforming options. If the manufacturer (or authorized category C distributor) solder dips or reforms the leads as part of normal production, or as a corrective action for solderability test failure, the following shall apply:

- a. Following any solder dip or reforming process, the post-test electrical measurements specified in group A, subgroup 1 shall be performed on a 200 piece sample for each eight hours of manufacturing. In the event of one or more defects, the individual production lot (or lots) from which the defects originated shall be subjected to 100 percent testing for dielectric withstanding voltage (DWV), insulation resistance (IR) (at +25°C), capacitance, and dissipation factor (DF), and must meet the percent defective allowable (PDA) requirements as specified in [4.6.1.2.2.1](#).
- b. PPM rate following the solder dip/reforming shall be reported each six months. The calculation method shall be in accordance with [EIA-554-1](#).

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Custodians:
Army - CR
Navy - EC
Air Force - 85
DLA - CC

Review activities:
Army - AR, AT, AV, MI
Navy - MC
Air Force - 19, 99

Preparing activity:
Army - CR

Agent:
DLA - CC

(Project 5910-2011-001)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using ASSIST Online database at <https://assist.daps.dla.mil>.